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WATER SUPPLY AND WATER QUALITY CONTROL STUDY, BUCK CREEK RESERVOIR, MIAMI RIVER BASIN, OHIO

PUBLIC HEALTH SERVICE

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY BUCK CREEK RESERVOIR MIAMI RIVER BASIN OHIO

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, REGION III
CHARLOTTESVILLE, VIRGINIA

JUNE 1965

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY
PROPOSED BUCK CREEK RESERVOIR
MIAMI RIVER BASIN
OHIO

Abstract

A study has been made which discloses no present or future need (to the year 2020) for storage in the proposed reservoir for municipal or industrial water supplies. Storage is needed in progressively greater amounts yearly for water quality control. These conclusions are based on analyses of existing water quality information and hydrologic, economic and demographic analyses. Future needs are based on projected population and industrial growth.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region III
Ohio River Basin Project
Evansville Field Station, Indiana

June 1965

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I INTRODUCTION

Request and Authority

This study was made pursuant to a request, from the Office of the District Engineer, U. S. Army Engineer District, Louisville, Kentucky, in a letter dated March 24, 1965, that the Public Health Service, furnish data "on water quality needs for the Mad River and Miami River at Dayton, Ohio", that should be considered in planning of Buck Creek Reservoir currently underway.

This study has been made in accordance with the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to the Water Supply Act of 1958 (Title III of Public Law 85-500 as amended by Public Law 87-88) and the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.).

Purpose and Scope

The purpose of this study is to determine the need for and value of storage of water in the proposed Buck Creek Reservoir to satisfy present and projected future municipal and industrial water supply needs and to determine the need for and value of storage in this reservoir for the regulation of streamflow for the purpose of water quality control. Other aspects of stream use and conservation are considered in order to determine the most efficient use of the streams.

This reservoir is proposed by the Corps of Engineers, primarily to furnish flood protection for the city of Springfield, Ohio, and reduce flood stages at all points downstream in the Mad River Basin.

The area considered in this study is located in southwestern Ohio and comprises Butler, Clark, Miami, Montgomery and Greene Counties and portions of Warren and Hamilton Counties. The specific area of interest includes the urbanized areas of Springfield, Dayton, Hamilton and Middletown located along the Mad and Miami Rivers. The evaluation of benefits is based on a project life of 50 years. The study covers the period from 1965 to 2020.

The Public Health Service has initiated a comprehensive study of water supply and quality control needs of the Ohio River Basin including the Miami River Basin, looking beyond available data to the collection of field data of waste sources and their effects on streams of the basin. The results of this study will be subject to review and possible revision based on the findings of the Public Health Service Comprehensive Study. However, the results of this study are considered adequate for project evaluation.

Acknowledgements

Information and cooperation provided by the following agencies are gratefully recognized:

U. S. Army Engineer District, Louisville, Kentucky

U. S. Geological Survey

State of Ohio - Department of Health

State of Ohio - Department of Natural Resources -

Division of Water

The Miami Conservancy District

II SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The U. S. Army Engineer District, Louisville, Kentucky, is proposing to locate a reservoir for flood control and associated purposes on Buck Creek, a tributary of the Mad River. The Mad River is a major tributary of the Miami River.

2. The study area is that portion of the Miami River drainage area lying along Buck Creek, the Mad River from Springfield to Dayton, and the Miami River from Dayton to the mouth, comprising the Springfield, Hamilton-Middletown, and Dayton Standard Metropolitan Statistical Areas and a portion of Warren County.

3. In 1960, approximately 1,044,000 persons lived in the study area, with approximately 833,500 classified as urban.

4. Daily average use and per capita water use as of 1960 in the major municipal water service areas were: Springfield, 14.3 mgd (156 gpcd); Dayton, 61.4 mgd (142 gpcd); Middletown, 8.4 mgd (144 gpcd); and Hamilton, 8.0 mgd (95 gpcd) all from ground sources.

5. Total self-supplied industrial average daily water use as of 1955 as reported by the State of Ohio, by service areas, was: Springfield, 0.8 mgd; Dayton, 48.2 mgd; Middletown, 24.3 mgd; Hamilton, 15.2 mgd; and Venice-Cleves, 45.3 mgd. Surface water use was 3.7 mgd in the Dayton

area, less than 0.1 mgd in the Middletown area, 1.2 mgd in the Hamilton area, and 26.4 mgd in the Venice-Cleves area. Approximately 88.8 mgd of industrial water is used by industry for cooling purposes exclusive of thermal-electric generating plants.

6. Major municipal waste sources and untreated population equivalents of waste in 1960 by service areas were: Springfield, 95,000 P.E.; Dayton 414,000 P.E.; Middletown, 68,000 P.E.; and Hamilton, 55,000 P.E. Springfield provides secondary treatment, the major communities in the Dayton area provide secondary treatment, Middletown provides primary treatment, and Hamilton provides secondary treatment.

7. Organic waste discharges from paper plants are the major source of industrial waste in the Dayton, Middletown, and Hamilton service areas. According to a study by the State of Ohio,[2/] industries discharging directly to streams provide less than the equivalent of secondary treatment to wastes amounting to approximately 287,000 P.E. in the Dayton service area, 175,500 P.E. in the Middletown service area, and 209,000 P.E. in the Hamilton service area. An oil refinery in the Cleves service area with a waste of 90,000 P.E. before treatment adequately treats its waste before discharge.

8. The surface water and groundwater in the study area are primarily hard waters of the calcium bicarbonate or magnesium carbonate type, but are suitable for most municipal and industrial uses after conventional treatment.

Conclusions

1. The population in the study area will be about 2,222,000 by the year 2020, of which over 90 percent will be classified as urban.

2. There is no apparent need for storage for municipal and industrial water supply during the study period provided adequate measures are taken to recharge ground storage aquifers during periods of medium to high flows in the streams and new well fields are added to make full use of available groundwater.

3. There is a current and projected need for storage for stream-flow regulation for quality control in the Miami River at Dayton. Even with the provision of adequate waste treatment assumed to be 85 percent BOD reduction of the total organic constituents for municipal wastes and equivalent treatment for industrial wastes, summer flow of 1400 cfs at Dayton will be needed by 2020 to assimilate the estimated residual organic waste load of 269,000 P.E. at Dayton.

4. An annual draft-on-storage* of 203,000 acre-feet will be needed by the year 2020 for water quality control purposes below the Dayton sewage treatment plant outfall. A portion of this draft-on-storage estimated by the Corps of Engineers to be in the range of 20,000 to 40,000 acre-feet, can be provided from the Buck Creek Reservoir.

*Annual draft-on-storage is the sum of the incremental excesses of needed releases over inflow during a climatic year.

5. The minimum annual value of the benefits for providing the entire draft-on-storage would be $1,750,000. The annual value of the benefits attributable to the Buck Creek Reservoir are in the range of $172,000 to $345,000 based on a 50 year project life, an interest rate of 3-1/8 percent, and an adjustment for operation and maintenance costs. Single purpose reservoirs are used in this determination as the most likely alternative to the proposed project.

6. Provision of storage to meet a portion of the quality control needs at Dayton from a reservoir at the proposed Buck Creek site will, by assuring minimum flows, maintain 7.3 miles of Buck Creek from the reservoir to the confluence with the Mad River and 24 miles of the Mad River as a desirable stream free of the effects of excessive pollution, will improve conditions in the Miami River from Dayton to its mouth and will enhance the recreational use of the streams by improving the environment for aquatic life, will contribute to the aesthetic enjoyment of the streams by recreational users and riparian property owners, and may be considered widespread in nature.

7. To insure discharge of good quality water below the dam, it is recommended that multiple outlets at three levels or some modification thereof be provided to make possible selection of the best quality of water available.

III PROJECT DESCRIPTION

Location

The Buck Creek Reservoir site is located in Clark County, east of Springfield, Ohio, 7.3 miles above the mouth of Buck Creek, a principal tributary of the Mad River.

The stream reach areas affected by flow releases from the Buck Creek Reservoir lie along the 7.3 miles of Buck Creek to its confluence with Mad River at Springfield, Ohio; the 26.2 miles along Mad River to its confluence with the Miami River at Dayton; and along 85 miles of the Miami River below Dayton as it flows past West Carrollton, Miamisburg, Franklin, Middletown and Hamilton to its confluence with the Ohio River.

Streamflow

The drainage area above the Buck Creek Reservoir Site is 82 square miles. Records from a U. S. Geological Survey gaging station located at New Morefield, Ohio, upstream from the reservoir site, measures flows from a drainage area of 67.3 square miles. Discharge records show a maximum flow of 5150 cfs, a minimum flow of 12 cfs, and an average discharge for 16 continuous years of record (1942-1958) of about 66 cfs.

Water Quality

Surface waters in the reach of Buck Creek above the reservoir site average about 370 mg/l in dissolved solids and 335 mg/l in hardness. Adverse effects from organic wastes would not be expected in Buck Creek Reservoir as there are no large communities located in the drainage area.

Pertinent Data

The Buck Creek Project is being considered for flood control, water supply, water quality control, recreation, fish and wildlife and related activities.

Design data show the proposed dam would be of rolled rock-fill, with an impervious core, and sand and gravel shell, approximately 70 feet high and 6,200 feet in length. The outlet works is to consist of a control tower with three sluice gates discharging to a 14 foot diameter circular concrete conduit along the left bank leading to the stilling basin.

Pertinent data on storage allocations, surface area and depth are tabulated below:

	Elevation	Capacity Acre-Ft.	Area Acres
Top of Dam	1,040	-	-
Flood Control Pool	1,023	31,300	2,720
Water Quality & Seasonal Pool*	1,012	22,430	1,940
Minimum Pool	995	9,970	1,010
Stream Bed	970	-	-
Total		63,700	

*Allocation of storage for water quality and seasonal pools have not been finalized.

IV STUDY AREA DESCRIPTION

Location and Boundaries

The Miami River drainage area is located in the southwestern portion of the State of Ohio and the southeastern portion of the State of Indiana (See Figure 1, page A-13). The portion of the drainage area in Ohio lies principally within the counties of Butler, Preble, Montgomery, Darke, Miami, Clark, Champaign, Shelby and Logan and partially within Greene, Warren and Hamilton. The portion of the drainage area in Indiana lies principally within the counties of Wayne, Fayette, Union and Franklin.

The Miami River rises in Logan County Ohio, flows in a general southwesterly direction for approximately 172 river miles to the confluence with the Ohio River near the Ohio--Indiana State Line and drains a total area of 5385 square miles, 3950 in Ohio and the balance in Indiana. The adjacent drainage areas are, the Scioto and Little Miami Rivers on the east, the Maumee River on the north, the Wabash River on the west and the Ohio River on the south.

The major tributaries of the Miami River are as follows:

Major Tributary	Miles above Mouth	Drainage Area Sq. Miles
Whitewater River	5	1590
Fourmile Creek	38	320
Twin Creek	60	320
Mad River	85	656
Stillwater River	86	639
Loramie Creek	126	260

The Whitewater River enters the Miami River at a point five miles above the confluence with the Ohio River and drains primarily the Indiana Counties. The Miami River Basin above the Whitewater River confluence, drains primarily the Ohio counties. In this report, the Miami River Basin is defined as including that portion of the basin drained by the Miami River and tributaries above the confluence of the Whitewater River. Since the reservoir being studied is planned on Buck Creek, a tributary of the Mad River, this study is primarily concerned with the reach of the Mad River from Springfield to its confluence with the Miami at Dayton and the Miami River from Dayton to the mouth. The study area is therefore defined as comprising Butler, Montgomery, Miami, Clark, and Greene Counties and portions of Warren and Hamilton Counties in the State of Ohio.

Geography and Topography

The entire Miami River drainage area lies in the Glaciated Till Plains division of the Central Lowlands physiographic province. Predominantly, the topography is typified by level to gently rolling plains which are broken by the wide valleys of the major streams.

Glaciation by at least two major ice sheets has affected the watershed. The Wisconsin sheet going down to about Middletown and the Illinois covering the entire area and filling in many of the preglacial river channels.

The effect of the glacial deposits is of importance because of their influence o[illegible]e rainfall-runoff relationship. Over the Miami Valley the glac[illegible]al drift is deep, exceeding 300 feet in places, but thinning toward the south.

Due to effects of glaciation the river shows a flat profile near its headwaters, steeper toward the south and fairly steep near its mouth. Average values for the slope of the Miami River are 2 feet per mile in the upper reaches and 3.3 feet per mile below Dayton. The Stillwater and Mad Rivers have average slopes of 4 feet per mile and 6 feet per mile respectively.

The bedrock exposed consistsof limestone, dolomite and shale of the Ordovician and Silurian Systems which are laid generally in a dense strata not favorable to the storage of large volumes of groundwater. In the upper reaches of the basin, however, the dolomites are predominate and it is possible that they influence the streamflow by groundwater storage.

Buck Creek is a major tributary of the Mad River, has a drainage area of 141 square miles, and is shaped roughly in the form of an equilateral triangle with Springfield at one apex. It rises in Champaign County and flows in a southwesterly direction for a distance of 19 miles where it is joined by Beaver Creek at the eastern limits of Springfield. Thereafter it flows in a westerly

direction through Springfield for about six miles to its junction with the Mad River, 26.2 miles above the mouth. From the uplands of Buck Creek the terrain slopes from elevation 1,300 to about elevation 900 in the vicinity of Springfield.

From Springfield the Mad River flows southwest a distance of 26 miles to its confluence with the Miami River at Dayton, Ohio, 85 miles above its mouth. Ten miles below Springfield, the Mad River enters the area of the flood control pool (elevation 835) of Huffman Reservoir, a flood retarding reservoir built by the Miami Conservancy District for flood protection on the Lower Mad and Miami Rivers.

Climate

The Miami River Basin has a typically humid continental climate characterized by moderate extremes of heat and cold, and wetness and dryness.

The average annual temperature varies from 55°F in the southern portion of the basin to 51°F in the northern portion of the basin. Range of mean temperature varies from 33°F in January to 77°F in July in the southern portion of the basin and from 29°F in January to 74°F in July in the northern portion. Also characteristic of the area are extremes of below 0°F in the winter months to above 100°F during the summer months.

The average precipitation varies from about 39 inches in the south, to 33 inches in the north, generally well distributed throughout the year.

Principal Communities and Industries

Major communities in the study area are Dayton, Springfield, Hamilton and Middletown, Ohio.

The leading industries in the study area are those concerned with paper and metal. The majority of the pulp and paper mills are located on the Miami River between Tipp City and Hamilton. Metal plants produced a wide variety of products ranging from structural steel to intricate machinery and are located primarily in the larger cities in the basin. Industries related to agriculture, such as the dairy, meat packing and canning industries, are prevalent in the basin and constitute a large portion of industry in the smaller communities. There are also other various types of industries such as textiles, breweries, rubber, oil refinery, chemical and tobacco.

V WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

Surface

In the study area of the Miami River Basin, flood flows have been regulated since 1920 by one of the most elaborate flood control reservoir systems in the country. The reservoirs are located on tributaries in the basin and were constructed and are operated by a local authority, the Miami Conservancy District. The reservoir dams by nature of their design, which does not involve any movable parts, are non-operating during periods of normal flow.

A portion of the basin was traversed by the Miami-Lake Erie Canal, which by 1845 connected Cincinnati and Dayton with Lake Erie at Toledo. From Cincinnati the Canal followed Mill Creek through Hamilton County to Hamilton in Butler County and then followed the Miami River through Middletown, Dayton, and Piqua. The canal route then followed Loramie Creek and crossed the divide into the Maumee River Basin. Small portions of this canal remain intact at Hamilton, Middletown and Franklin, and serve as a source of water for hydropower at Hamilton. During periods of low flow, it is possible to divert the entire flow of the river through these portions of the canal leaving the stream bed of the river virtually dry in the aforementioned reaches.

There are no large natural lakes in the basin and no reservoirs regulating low flows. Three reservoirs were constructed to supply water to the canal, two of which are in the Miami River Basin. Indian Lake (114,000 acre-feet of storage) on the North Fork of the Miami River

and Loramie Reservoir (11,000 acre-feet of storage) on Loramie Creek are located at the northern edge of the basin. Both lakes are now operated as State owned recreational facilities and have no direct effect on flow conditions of streams in the Great Miami Basin.[1/]

Ground

The present course of the Miami River occupies a part of a much wider and deeper ancestral river valley over much of its present location. Glaciation by at least two major ice sheets overran most of the basin, changing drainage patterns and, upon receding, filled the pre-glacial drainage channels with layers of glacial materials ranging in size from coarse gravel to fine sand. The total thickness of drift varies from 200 to 300 feet in the deeper parts. Groundwater storage influences low streamflow and in the Mad River Valley, the yields are among the highest in the State of Ohio. Yields for the Miami River below Dayton are about average for the State.

Practically all water supplies in Butler, Clark and Montgomery Counties are obtained from the gravels of the valley-train deposits. However, wells drilled in glacial drift in upland areas are seldom satisfactory sources for large quantities of water.

Recharge of groundwater is from precipitation on the valley floor, infiltration from the river and underflow through the buried valley from upstream areas. Most of the recharge from precipitation occurs during the nongrowing season.[4/] Conditions favoring river infiltration are known to occur in parts of Dayton, Middletown and Hamilton where total pumping from wells averages approximately 160-170 mgd. The condition favorable to river infiltration occurs over approximately 25% of length of the river between Dayton and Hamilton and it is believed that only a small part of the groundwater potential in the Miami River below Dayton has been developed.[4/]

Many dams have been constructed in the river, but since the dams are quite low they have only minor effects on streamflow. Streamflow data are available at the stations listed in Table V-1.

TABLE V-1
Streamflow Data
Proposed Buck Creek Reservoir

Location	Drainage Area Sq. Mi.	Records Avail. Yrs.	Avg. Disc. cfs	Min. Flow date cfs	Max. Flow date cfs	7 day avg. 1 in 10 yr. [11] cfs	1 day in 30 yrs. [11] cfs
Miami River							
Hamilton	3639	32	3179	9/26-27/41 100	3/26/13[a] 352,000	281	161
Miamisburg	2718	26	2305	9/7/41 148	3/26/13[b] 257,000	223	
Dayton[c]	2513	34	2069	9/26/41 78	3/26/13[b] 250,000	175[d]	89[d]
Taylorsville	1155	45	988	1/2/45 30	3/- /13 127,000	46	30
Sidney	545	38	476	9/23/35 8	3/25/13 44,000	18	7.7
Mad River							
Near Dayton[e]	635	49	621	8/6-9/34 91	3/25/13 75,700	224	78
Springfield	490	50	483	9/15/04 30	3/25/13 55,400	115	89
Urbana	162	30	141	2/2-3/45 24	1/22/59 8,000	33	
Stillwater River							
Englewood[f]	646	38	574	9/30/44 3.7	3/ - /13 85,400	12	4.1

a/ Regulated by five retarding basins above station beginning in 1920.

b/ Regulated by four retarding basins above station beginning in 1920.

c/ Does not include return flows from Dayton.

d/ Water is diverted above station for use by Dayton.

e/ Station located above diversion for Dayton well field recharge.

f/ Station located 8 miles above mouth.

Quality of Water Available

Surface

Surface waters of the Miami River contain moderate amounts of dissolved solids with an average concentration of about 400 mg/l and are primarily hard waters of the calcium bicarbonate or magnesium carbonate type, averaging about 300 mg/l.

Typical chemical analyses of samples collected by the U. S. Geological Survey at several stations on the Miami River and its tributary streams are shown in the Appendix, Table V-2.

The primary cause of adverse water quality in the Miami River Basin is organic wastes from municipal sewerage systems and industrial outfalls. The discharge of heat loads during periods of low flow are of significance in the lower reach of the river at Miamisburg and Dayton, Ohio.

Ground

Waters from ground sources average about 450 mg/l of dissolved solids and are hard waters of the calcium bicarbonate or magnesium carbonate type averaging about 350 mg/l. Iron content is generally low, less than 1.5 mg/l in water obtained from shallow wells up to 130 feet deep located in the valley train deposits, but is higher in the deeper wells located in this material and in limestone stratas underlying the basin. Analyses of samples taken from what is believed to be representative wells are shown in the Appendix, Table V-3.

VI THE ECONOMY

Introduction

Population and industrial activity in an area are the basic elements in determining present and future water requirements in terms of quantity and quality. As population and industrial activity increase, the demand for additional water supply and the production of water-borne wastes also increase. The projections of this section provide a basis for estimating the future water supply and water quality control needs in subsequent sections of this report.

Present

The stream system of which Buck Creek is a part, flows through a rather densely populated urban and industrial complex. Buck Creek originates in Champaign County, Ohio, flows south into Clark County, through the city of Springfield, and joins the Mad River just west of Springfield. The Mad River joins the Miami River at Dayton. The Miami River, after leaving Dayton, flows southwest through Middletown and Hamilton, and west of the Cincinnati metropolitan area and joins the Ohio River near the Indiana-Ohio border. Three Standard Metropolitan Statistical Areas are involved; i.e., Springfield, Dayton, and Hamilton-Middletown.

Manufacturing is the main industrial activity of the area with the most important categories as measured by employment as follows: Machinery, Motor Vehicles, Primary Metals, Printing and Allied Products, Fabricated Metals, Food and Kindred Products, and Other Non-Durable Goods (including Paper and Petroleum). In the four counties of Butler, Clark, Miami, and Montgomery, there were about 500 plants employing over 20 employees in 1964. The distribution of these plants by size and county and the 1962 employment in industries which may have a significant impact on the water resources in the region are shown in the Appendix, Tables VI-1 and VI-2, respectively. There is one paper mill in the northwest corner of Warren County which as a capacity of 95 tons per day of a defibrated or exploded type of pulp.

Government is a basic industry in this area with the Wright-Patterson Air Force Base located near Dayton.

The population of the study area increased from 787,800 in 1950 to 1,043,900 in 1960--an increase of about 33 percent. Eighty percent, or 833,500, of the 1960 population was in the urbanized areas. A small megapolis is forming which runs from Columbus through Springfield, Dayton, Middletown and Hamilton, to Cincinnati. The interstate highway system already extends from Springfield to Cincinnati and will encourage the development of this megapolis.

Future

The expected rate of growth of the output in the major industrial categories in the four counties are shown in the Appendix, Table VI-5. The indices of output were derived from the Projective Economic Study of the Ohio River Basin made by the A. D. Little Company, Inc. Output, as measured in constant 1960 dollars, is expected to increase in all of the selected categories by at least 45 percent by 1980, and by 2010 some of the increases in output go as high as 700 percent.

Population projections are included in Tables VI-3 and VI-4. These are also derived from the A. D. Little Company, Inc. Projective Economic Study of the Ohio River Basin. As indicated in Table VI-4, an increase of about 37 percent in the urbanized area population in the service areas is expected by 1980 and an increase of about 150 percent by 2020.

TABLE VI-3

Population
Study Area - Selected Counties and SMSA Areas - Historical and Projected
Proposed Buck Creek Reservoir Project

	1950	1960	1980	2000	2020
Dayton SMSA					
Greene County	58,900	94,600			
Miami County	61,300	72,900			
Montgomery	398,400	527,100			
Sub-Total Dayton SMSA	518,600	694,600	900,000	1,170,000	1,550,000
Hamilton-Middletown SMSA					
Butler County	147,000	199,100	270,000	340,000	430,000
Sub-Total Hamilton-Middletown SMSA	147,000	199,100	270,000	340,000	430,000
Warren County (Part)					
Franklin Twp.	10,300	18,800	24,000	30,000	37,000
Sub-Total Warren Cty.(Part)	10,300	18,800	24,000	30,000	37,000
Springfield SMSA					
Clark County	111,700	131,400	150,000	175,000	205,000
Sub-Total Springfield SMSA	111,700	131,400	150,000	175,000	205,000
Study Area Total	787,800	1,043,900	1,344,000	1,715,000	2,222,000

TABLE VI-4

Water Service Areas
Study Area - Urban Population
Proposed Buck Creek Reservoir Project

	1950	1960	1980	2000	2020
Dayton Urbanized Area	346,900	501,700	720,000	960,000	1,400,000
Hamilton Urbanized Area	63,700	90,000	124,000	190,000	240,000
Middletown including Lemon & Madison Twp. in Butler Cty. Franklin Twp. in Warren Cty.	61,000	85,000	110,000	157,000	170,000
Springfield including Bethel, Morefield, Mad River and Springfield Twps.	99,500	116,900	133,500	160,000	182,400
TOTAL	571,100	793,600	1,087,500	1,467,000	1,992,400

VII WATER REQUIREMENTS--MUNICIPAL AND INDUSTRIAL

Past and Present Water Use

Most of the communities and many industries in the Miami River Basin obtain their water supplies from groundwater sources. The surface water in the Miami River Basin and its tributaries serve as a source of water for industry, primarily for cooling purposes, and as a source of supply for two communities in the northern part of the basin. The communities in the study area with populations over 1000 having central water systems together with the population served and water use for these communities are shown in the Appendix, Table VII-1. The self supplied water use for industries in or near these communities is shown in the Appendix in Table VII-2. The same type information for other communities in the Miami River Basin is shown in the Appendix, Tables VII-3 and VII-4.

Municipal

There are forty-five communities with populations over 1000, in the Miami River Basin having central water systems. Municipal systems serve a population of about 829,000 with an average daily use of approximately 112 mgd. Of this total population about 30,500 are served from surface sources with a water use of approximately 4.9 mgd.

All of the communities in the study area obtain their water supplies from ground sources. As of 1960, along the reaches of the Mad River from Springfield to Dayton and the Miami River from Dayton to its confluence with the Ohio River, approximately 671,000 persons use an average of 92.3 mgd, representing over 80% of the total municipal water use in the basin.

Following in Table VII-5, is a summary of municipal water use by stream reach in the major service areas:

TABLE VII-5
Study Area-Summary-Water Resources and Supplies-Municipal
Proposed Buck Creek Reservoir Project

Stream	Service Area	Population Served	Average Daily Water Use-mgd	Per capita Water use-gpcd
Mad River	Springfield	91,850	14.3	156
Miami River	Dayton	432,400	61.4	142
Miami River	Middletown	58,300	8.4	144
Miami River	Hamilton	85,300	8.0	94

Industrial

Information gathered in 1955 by the State of Ohio, published in August of 1960,[6/] and listed in Tables VII-2 and VII-4 in the Appendix, shows that the total water use for industrial purposes in the Miami River Basin was about 164.3 mgd with 23.4 mgd obtained from public supplies and about 141.1 mgd developed privately. Of the 141.1 mgd developed privately, 107.0 mgd was from ground sources and 34.1 mgd was from surface sources. Of the total industrial water use, 94.5 mgd was used for cooling purposes, not including that which was used by thermal electric power plants.

Over 96% of total water developed for industrial purposes in the Miami River Basin, was used in the study area along the reach of the Mad River from Springfield to Dayton and along the reach of the Miami River from Dayton to the mouth. Total water use in these reaches, was about 154.3 mgd, with 20.5 mgd obtained from public supplies. Of the 133.9 mgd developed privately, 102.5 mgd was from ground sources and 31.4 was from surface sources with 88.8 mgd used for industrial cooling purposes. The foregoing figures do not include cooling water needs for thermal electric power plants.

Thermal electric power plants in the study area are the major users of surface water in the basin. This water is used primarily for cooling purposes and is returned to the stream unchanged except for an increase in temperature. During periods of low flow, recirculation is required in some of the pools. The major generating plants and their approximate water use are shown in Table VII-6.

TABLE VII-6
Study Area-Thermal Electric Power Plants
Proposed Buck Creek Reservoir Project

Location	Type	Capacity (KW)	Cfs
Mad River	Steam	75,000	113
Dayton	Steam	444,100	500
Miamisburg	Steam	414,000	600
Hamilton	Steam	58,500	67

One hydro-electric plant in the basin is located at Hamilton, generating 3,200 KW with water use of 1350 cfs at maximum generating capacity.

Recreation use is made of some stretches of the stream, mostly boating and water skiing in the pools created by low head dams. Fish are taken from the stream in the lower reaches.

Water is used in connection with gravel mining activities but, much of this is recirculated in pits adjacent to the activity or if withdrawn, is used and returned to the stream with very little consumptive loss.

Use of water for irrigation in agriculture has been of very limited importance but may be expected to expand in the coming years. 7/

Existing Sources - Surface and Groundwater

Quantity

Due to the presence of deep unconsolidated deposits of sand and gravel in ancestral river valleys and a generous supply of rainfall, the basin has not experienced a shortage of groundwater. It has been established that there is a definite relationship between stages of the river and the condition of the shallow acquifer adjacent to the river. 1/ Local conditions of heavy drawdown have occurred in this acquifer, but properly designed infiltration basins to increase recharge during medium to high flows and strategically spaced wells would probably alleviate this situation. 4/

The city of Dayton artificially recharges its well field by diverting flow from the Mad River into a series of ditches and lagoons. The State of Ohio reported the results of tests in connection with this well field, indicating that during periods of diversion and recharge approximately 80% of the water withdrawn can be attributed to infiltrated surface flows.[1/]

Quality

Due to increasing population growth and industrialization there has been a steady decline in the quality of surface water especially at lower flows. This is primarily due to the discharge of organic constituents and inadequate assimilative capacity of the streams at lower flows in critical locations. Use of surface water for industrial cooling will be adversely affected by increased circulation behind low head dams and downstream users will be forced to use higher temperature influent water unless offstream cooling methods are used.

Groundwater, although hard, is suitable for most municipal and industrial uses after conventional treatment.

Future Municipal and Industrial Water Requirements

Municipal

Economic and demographic analyses reveal an expanding population with increased urbanization and industrialization in the study area. The present per capita water use in the service areas of Springfield (156 gpcd),

Dayton (142 gpcd), and Middletown (144 gpcd) indicates that a large number of light industries and commercial establishments are dependent on public water supply systems for their supplies.

The Senate Select Committee on National Water Resources in Committee Print No. 7 shows the average per capita water use for the United States as 147 and for the State of Ohio, 149. The water use in the aforementioned water service areas closely approximate these figures.

The Hamilton service area with a per capita water use of 94 gpcd is appreciably below the National and State average.

The Senate Select Report projects the average water use as follows:

	1954	1980	2000
United States	147	148	152
Ohio	149	147	147

However, it is pointed out in the Senate Select Committee report that the foregoing figures have been developed on a conservative basis and gallons per capita day of average municipal use could conceivably increase to about 185 gpcd in 1980 and perhaps to 225 gpcd in year 2000 with a possible leveling off thereafter.

Present and projected water use in gallons per capita per day for water service areas in the study area are listed below:

Service Area	Present	1980	2000	2020
Springfield	156	160	165	170
Dayton	142	150	160	170
Middletown	144	150	160	170
Hamilton	95	115	135	150

The foregoing figures include allowances for commercial and incidental industrial use.

The estimated populations to be served by central water systems and estimated water use for 1980, 2000 and 2020 are listed in Table VII-7.

TABLE VII-7
Study Area-Estimated Future Municipal Water Needs
Proposed Buck Creek Reservoir Project

	1980		2000		2020	
Service Area	Estimated Population Served	Estimated Avg.Use mgd	Estimated Population Served	Estimated Avg.Use mgd	Estimated Population Served	Estimated Avg.Use mgd
Springfield	133,500	21.4	160,000	25.6	182,400	31.0
Dayton	720,000	108.0	960,000	144.0	1,400,000	238.0
Middletown	110,000	16.6	157,000	25.1	170,000	28.9
Hamilton	124,000	14.3	190,000	21.8	240,000	36.0

Available groundwater capacity appears to be adequate to meet the needs of all communities in the study area provided new well fields are developed. In the Dayton service area, by 2020, the estimated use indicates a four fold increase over the present use. Taking into consideration the

diversion and recharge practices at the Dayton well field, projected water use will exceed the low day in 30 year recurrence (78 cfs) in the Mad River. However, groundwater capacity in the Dayton area appears to be adequate providing groundwater storage acquifers are recharged during periods of medium to high flows and wells are located strategically to develop new areas. It is therefore concluded that there is no need for storage for municipal water supply in Buck Creek Reservoir.

Industrial

As shown in Section VI, The Economy, there are many heavy water using industries located in the basin. Future self-supplied industrial water needs, shown in Table VII-8, were estimated on the basis of the industrial water use inventory of the State of Ohio [6] and the assumption that water use for industrial purposes will increase at the same rate as projected employment.

TABLE VII-8
Study Area-Present and Estimated Future Self Supplied Industrial Water Needs
Proposed Buck Creek Reservoir Project

	1955		1960		1980		2000		2020	
Service Area	Grd. mgd	Surf. mgd	Grd. mgd	Surf. mgd	Grd. mgd	Surf. mgd	Grd. mgd	Surf. mgd	Grd. mgd	Surf. mgd
Springfield	0.8	-	0.9	-	1.1	-	1.2	-	1.3	-
Dayton	44.5	3.7	48.2	4.0	58.7	5.30	64.6	5.9	72.1	6.5
Middletown	24.3	0.1	22.7	0.1	27.7	0.1	30.5	0.1	34.0	0.1
Hamilton	13.9	1.2	15.2	1.3	18.4	1.6	20.3	1.8	22.6	2.1
Cleves-Venice	19.0 [a]	26.4	20.6 [b]	28.6	25.1	34.8	27.6	38.3	30.8	42.8
TOTAL	102.5	31.4	109.2	34.0	133.0	41.8	146.4	46.1	163.3	51.5

a/ 11.4 mgd diverted to the Mill Creek drainage area.

b/ Approximately 13 mgd diverted to the Mill Creek drainage area.

Much of the water developed for industrial use will be for cooling purposes and will be returned to surface streams for reuse at downstream points unchanged except for an increase in temperature.

Groundwater sources appear to be adequate to satisfy projected needs provided additional well fields are developed. Projected surface water needs by 2020 will not exceed the low day in 30 years flow in the Miami River in the various service areas. Therefore, there is no foreseeable need for storage in the proposed Buck Creek Reservoir for industrial water supply.

VIII WATER QUALITY CONTROL

The quality of water determines the uses that can be made of it, and unless proper quality is maintained, possible economic benefits of its use will be lost and public health may be endangered. The objectives used in evaluating quality conditions in the Miami River Basin have been based on the present and prospective municipal water supply, general recreational use, the preservation and propagation of fish and aquatic life and wildlife along the Mad and Miami Rivers, and the use of these streams as a source of water for industries along its banks.

Organic wastes from municipal or industrial sources are considered in terms of their effect on dissolved oxygen resources of the Mad and Miami Rivers.

Organic waste loads are projected on the basis of the population increase and industrial growth shown in Section VI of this study. This study considers only those organic wastes discharged to surface streams which remain after adequate treatment. Adequate treatment is considered as 90 percent removal of biodegradable wastes reaching treatment plants, but it is recognized that under present conditions of collection, wastes such as storm sewer discharges, overflows from combined sewers, surface drainage and street washings are not collectable and therefore can not be treated. Discharges of treated wastes and discharges from storm sewers

and surface drainage in sufficient quantities could create adverse water quality conditions in the stream if adequate assimilative capacity is not available. On the basis of available information on these other sources an overall removal of 85 percent has been used as the basis for design.

Inorganic wastes are discharged by the chemical, steel and metal finishing industries in the study area. Examples of these wastes are toxic ions of metals in critical concentrations which can be detrimental to humans, animals, fish and other wildlife; acid wastes which can affect the pH and alkalinity of a stream and render it unsuitable for industrial and agricultural uses and aquatic life; neutralized acid wastes which can increase the sulfate hardness of the receiving stream. Spent pickle liquor from the metal finishing industry (which can contain substantial quantities of iron) and discharges from foundries, blast furnaces and the descaling operations of rolling mills which contain substantial quantities of iron can form a metallic "floc" which, in reaches of the stream carrying significant residual organic loads, precipitates out the organic matter to the bottom of the stream covering food sources normally available to aquatic life. The effects on water quality of inorganic wastes are not evaluated in this study since these wastes will be effectively controlled at the source.

Municipal and Industrial Pollution

Communities in the study area with over 1000 population which collect wastes, and industries adjacent to these communities which discharge directly to the streams are listed in the Appendix, Table VIII-1.

Listed in the Appendix, Table VIII-2 is the same type information for other communities in the Miami River Basin.

At present, Springfield on the Mad River provides secondary treatment for wastes having a population equivalent (P.E.) of approximately 95,000.

In the Dayton service area, the municipalities of Fairborn, Dayton, Moraine City, Trotwood and West Carrollton collect and provide secondary treatment for wastes having a population equivalent of approximately 404,300. Miamisburg's municipal wastes totaling 9500 P.E. presently receive primary treatment. Untreated or incompletely treated waste discharges amounting to 287,000 untreated P.E. from paper plants in the Dayton to Maimisburg reach of the Miami River contribute to pollution.

In the Middletown service area, Middletown and Franklin provide secondary treatment for wastes having a population equivalent of approximately 68,000. Industrial wastes amounting to 175,500 P.E. from a pulp mill at Franklin and paper plants at Franklin and Excello receive incomplete treatment.

In the Hamilton service area, the city of Hamilton provides secondary treatment for wastes amounting to approximately 55,000 P.E. A paper plant provides less than secondary treatment for wastes amounting to 209,000 P.E.

In the reach from Hamilton to Cleves at the mouth of the river, an oil refinery provides secondary treatment for wastes amounting to approximately 93,000 P.E.

Thermal power generating plants at Dayton and Miamisburg contribute sizeable heat loads to the Miami River. See Table VII-6 preceding.

Population projections and projected industrial growth for the study area indicate that increasing residual waste loads, remaining after adequate treatment, will be discharged to the streams. The summary of the projected waste loads for the study area is shown in the Appendix, Table VIII-3.

By 2020,projected waste loads discharged to the stream, after 85 percent removal of organic wastes, will total at Springfield 27,500 P.E.; at Dayton, approximately 269,000 P.E.; at Middletown approximately 61,600 P.E.; at Hamilton approximately 82,000 P.E.; and in the Venice-Cleves service area approximately 20,400 P.E.

Water Quality Objectives

The effects of organic loads on the dissolved oxygen content of the streams in the basin are considered as the prime indicator for pollution control and flow regulation. In setting water quality objectives for streams for the protection of aquatic life, mere survival is not enough, and the minimum level selected should be suitable for the continuous maintenance of satisfactory fish life and fish food organisms. Objectives are therefore based on the environmental requirements of the fish species present in the stream. On the basis of studies by the Public Health Service in the Cincinnati area, it was concluded that for a well-rounded warm water fish population, dissolved oxygen concentrations should not be below 5 mg/l for more than 8 hours of any 24-hour period and at no time should it be below 3 mg/l.[8] Based on these considerations a dissolved oxygen goal of a minimum of 4 mg/l at low flow conditions has been used for purposes of this report as a reasonable dissolved oxygen concentration adequate to maintain aquatic life and to assure present and expected recreational use of the streams.

The State of Ohio, Department of Health, Division of Sanitary Engineering in their report[9] on the Miami River established a minimum dissolved oxygen objective of 4 mg/l in those areas where the maximum utilization of the self purification capacity of the stream is essential. This goal is concurred in by the Public Health Service. The required reduction of organic wastes established by the Ohio Department of Health under present conditions of population and industrial development with the critical flow defined as an annual seven consecutive day average flow which is equalled or exceeded in 80 percent of the years, range on the

main stem from a 35 percent reduction of untreated waste at Cleves to 93.5 percent reduction at Dayton and 85 percent reduction above Dayton. Reductions required on the main tributaries are 85 oercent on the Mad River and 65 percent to 95 percent on the Stillwater River.

At critical low flow, based on the Ohio Department of Health projections of population growth and industrial expansion, reductions required at Dayton by 1980 would be 95 percent, below Dayton at Moraine City 90 percent, and at West Carrollton and Miamisburg 88 percent. By 2000, reduction required at Dayton would be 96 percent, Moraine City 93 percent, West Carrollton and Miamisburg 80 percent.

In the judgement of the Ohio State Department of Health, these required reductions in the future for the reach of the river in the Dayton service area, exceed that normally expected from conventional waste treatment facilities, and the need for flow regulation is recognized.

Other objectives of the State of Ohio for the Miami River, are as follows:

Toxic Ions - In Stream Concentrations

Ion	Max. Conc. mg/l
Cyanide as CN	0.15
Lead as Pb	0.10
Copper as Cu	0.30
Total Chromium as Cr	1.00
Cadmium as Cd	0.4
Zinc as Zn	0.3
Nickle as Ni	2.0

The above limitations are not permissive.

During field testing, concentrations were found by the State of Ohio personnel to be considerably below the maximum concentrations listed above.

Suspended Solids and Floating Materials - Substantially complete removal of settleable and floating material.

pH and Alkalinity - Discharges to be modified so as to maintain the pH of the stream water between 6.3 and 9.5 and to maintain a residual alkalinity of 75 mg/l.

Dissolved solids - No removal required at present for dissolved solids relating to hardness.

Color - Future removal will be required when economical methods are developed.

Coliform Concentration - In view of the use of reaches of the Miami River for recreational purposes, objectives for maximum coliform concentrations should be considered. However, coliform reductions can be more effectively achieved by chlorination of sewage plant effluents than by dilution, and therefore flow regulation for this purpose was not considered.

Heated Discharges - Objectives not presently formulated by the State of Ohio.

Although no objectives have been formulated by the State of Ohio regarding heated discharges, increased water temperatures lower the solubility of oxygen from the air into the stream water and increase the rate of deoxygenation of organic waste loads. During periods of low flow these discharges are recirculated in pool areas upstream from a dam. Thus residual waste loads exert a large demand for oxygen within a limited stretch of the river.

Excessive stream temperatures will prevent the maintenance of biological life in a stream. A review of the literature on the effects of abnormally high water temperatures on aquatic life indicates that fish can temporarily survive temperatures of 93°F but that with prolonged exposure to such abnormal temperatures drastic and severe changes will occur in aquatic biota.[8/] Sudden fluctuations in water temperatures of 9°F or more may also adversely affect fish life.[8/]

The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission recommends and the Public Health Service concurs that in order to maintain stream conditions capable of producing an annual harvestable fish crop, waste discharges should be controlled so that the temperature of the receiving water should not be raised above 34°C (93°F) at any place or at any time, nor raised above 23°C (73°F) during the months of December through April.

Flow Regulation

At Dayton there is presently a need for flow regulation. This need will increase with time due to projected population increase and industrial growth in order to maintain satisfactory stream conditions. If the need at Dayton is met, these flows will maintain satisfactory conditions in the river from Dayton to its mouth.

The minimum summer flow and estimated draft-on-storage needed to supply quality control flows below the Dayton sewage treatment plant outfall in 9 years out of 10 are shown below:

Year	Summer Flow, Cfs	Draft-on-Storage, acre-ft./yr.*
Present	585	45,000
1980	740	60,000
2000	970	110,000
2020	1400	203,000

The 7 day average base flow exceeded in 9 years out of 10, not including return flows from the Dayton area, is 175 cfs. In computing draft-on-storage, return flows from the Dayton area have been included.

Draft-on-storage needs have not been increased to cover such items as synchronization of reservoir releases with downstream needs and conveyance losses.

Flows listed above are for the month of maximum needs and flows needed in each season are indicated below:

Season	Flow Required Percent of Maximum
Summer (July, August, and September)	100
Spring and Fall (June and October)	90
(April and May)	70
Winter (January, February, March, November and December)	50

*Annual draft-on-storage is the sum of the incremental excesses of needed releases over inflow during a climatic year.

This table is not to be interpreted as an operating plan, but is being provided as an indication of a possible regulation pattern.

It is recommended that multiple level outlets or some modification thereof be constructed to provide flexibility in selection of good quality water for discharge downstream from the dam. Installation of recording instruments to indicate water quality at the several levels would facilitate operation of the flow release structures.

Part of the needed flow at Dayton can be provided from a reservoir on Buck Creek. Releases from this reservoir will also meet needs at Springfield. Surveillance is, however, necessary to assure that water quality releases are not diverted for municipal and industrial water supply.

The minimum summer flow needed to supply quality control flows below the Springfield sewage treatment plant outfall are shown below:

Year	Summer Flow, Cfs
1965	85
1980	120
2000	140
2020	160

The 7 day average base flow exceeded in 9 years out of 10 including return flows from Springfield is 115 cfs. A need below Springfield in the Mad River is thus indicated prior to the year 1980.

It must be emphasized that all calculated flows are based on the assumption that all municipal and industrial waste will receive adequate treatment prior to discharge to the streams.

IX BENEFITS

Alternate Plans

Several alternate plans suggested for satisfying the water quality objectives set forth herein for the Mad and Miami River are: (1) construction of holding ponds for treated effluent to enable release of waste during times of natural adequate flow; (2) discharging wastes to other drainage basins where adequate natural flow is available; (3) distillation of all wastes at their source, thereby preventing waste loading to the stream; (4) storage of water in a single purpose reservoir for release for the purpose of regulating flow during periods of low flow.

Waste holding ponds would not be a reasonable alternate because the size of the ponds would require acquisition of large land areas in a locality where property values are high. Piping treated effluent to the Ohio River would be too expensive. The nearest adjacent basin for discharge of wastes would be to the Little Miami River. This is impractical since discharges would be in the headwater reaches where flows would be inadequate to assimilate the wastes. Distillation of wastes at the present time is extremely expensive and therefore not economically feasible.

The most feasible plan that can be determined at the present time is storage in a reservoir for release to regulate flow in the Mad River below Springfield and in the Miami River from Dayton to its mouth.

Water Quality Control

Storage of water for water quality control purposes to increase flows during normal low flow conditions will provide both tangible and intangible benefits along Buck Creek through the city of Springfield, and along the Mad and Miami Rivers. Improved and more uniform water quality as well as lower water intake temperatures will result from increasing low flows and will benefit industries using surface water for industrial and cooling purposes. Assured water quality will improve conditions for recreation over 24 miles of stream on the Mad River and approximately 80 miles of stream on the main stem of the Miami River from Dayton to the mouth. If the flows described in Section VIII are provided at Dayton, the entire stream from Dayton to the mouth is expected to be able to satisfy the oxygen demands of the adequately treated organic wastes from communities and industries along its banks.

Regulation of flow will maintain the Mad and Miami Rivers as desirable streams free from the effects of excessive pollution and will contribute to the aesthetic enjoyment of the stream by recreational users and riparian property owners. Water of good quality will be an attraction to industrial and residential development in the Miami River Valley. Boating, picknicking, camping, sightseeing and recreational water oriented activities would be encouraged by providing a waterway free of the effects of pollution. Satisfying the water quality goals set forth in Section VIII by regulation of flow will increase the potential of the stream to support aquatic life, therefore the sport

of fishing would be enhanced in the study area. A population of 2,222,000 is expected within the study area by 2020 and a considerably larger number within reasonable travel distance in the Cincinnati and Columbus Metropolitan Statistical Areas.

Provision of flow regulation may be expected to enhance recreational opportunities over the length of the stream, maintain property values in the vicinity of the stream and encourage industrial development in the area and benefits are considered to be widespread in nature.

There are no estimates available at the present time pertaining to fishermen man days or recreational visitations in the reaches of the Mad or Miami Rivers, but preliminary information from the Corps of Engineers, U. S. Army indicates recreation visitor days are expected to be 550,000 per year at the reservoir.

Since technology has not progressed to the point that economical waste treatment methods capable of removing all of the organic materials from waste flows are available, only provision of added flows is considered capable of achieving the required quality improvements. Therefore, the alternative most likely to be used in the absence of the project would be two single purpose reservoirs developed for water quality control which would meet the needs at Dayton and Springfield. One reservoir would need to be located above Springfield either on Buck Creek or the Mad River and the other reservoir could be located above Dayton on a Miami River tributary stream. Considering the topography and present land use it is considered reasonably certain that sites can be found.

An annual draft-on-storage of 203,000 acre-feet is estimated to be necessary to meet streamflow requirements for the year 2020 in the Miami River below the Dayton sewage plant outfall in nine years out of ten. It is estimated, from general cost figures obtained from the Corps of Engineers for projects in the area north of the Ohio River, that the cost of two single purpose reservoirs having a combined capability of 203,000 acre-feet draft-on-storage would be on the order of $42,000,000.

The Corps of Engineers have not completed final determination of draft-on-storage available from the proposed Buck Creek Reservoir. Preliminary indications are that draft-on-storage is in the range of 20,000 to 40,000 acre-feet. Therefore, it is evident that the total storage for quality control releases at Dayton cannot be incorporated in the Buck Creek Reservoir.

The value of the benefits resulting from including quality control storage in projects to satisfy the needs at Dayton in 2020 based on a 50 year project life and an interest rate of 3-1/8 percent, would be $1,750,000 per year including operation and maintenance. The value of the benefits attributable to the Buck Creek Reservoir Project based on the range of 20,000 to 40,000 acre-feet draft-on-storage, would be on the order of $172,000 to $345,000 per year. A more refined estimate of the value of benefits should be made after final determination of draft-on-storage has been firmed up by the Corps of Engineers.

While the proposed reservoir could contribute to the regulation of flow in the Ohio River below the confluence of the Miami River and may improve water quality of the Ohio River at low flows, data at this time are inadequate for evaluation of tangible benefits that might result from such regulation. Ohio River flow regulation needs will be determined as part of the current Public Health Service Comprehensive Study. Such needs, when developed, can serve as a basis for determination of Ohio River water quality control benefits for the Miami River and similar projects. The value of the benefits could then be allocated to proposed developments in proportion to their contributions to water quality control.

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APPENDIX

TABLE V-2

Surface Water Quality [a]

Proposed Buck Creek Reservoir Project

Location	Date Sampled	Mean Discharge cfs	Fe	Ca	Mg	HCO_3	SO_4	Cl	NO_3	Dissolved Solids	Hardness [b]	pH
Miami River												
Above Stillwater at Dayton	Dec.1947	378	.02	82	32	309	78	8	5.6	-	336	8.1
	Apr.1948	2,180	.08	62	21	215	70	4.0	9.4	-	241	7.9
	Aug.1948	104	-	66	27	262	55	12	4.9	-	276	7.7
At Hamilton	Dec.1950	2,849	.12	91	32	328	88	15	3.4	423	423	7.8
	Feb.1951	21,320	.04	54	16	192	39	6.0	8.1	241	202	7.8
	Aug.1951	562	.03	89	37	337	126	29	.05	509	375	8.2
Stillwater River												
At Dayton	Dec.1947	116	.01	78	36	309	84	8	4.1	-	343	8.2
	Apr.1948	940	.09	74	27	266	54	6	15	-	296	8.1
	Aug.1948	40	-	59	31	260	61	8	2.6	-	275	7.7
Mad River												
At West Liberty	Dec.1947	115	.05	84	34	344	59	4.5	6.4	-	349	8.0
	Apr.1948	341	.06	85	32	333	58	4.0	8.2	-	344	8.0
	Aug.1948	90	-	79	35	340	63	2	6.4	-	341	7.8
Near Dayton	Dec.1947	421	.04	95	37	356	82	8.2	11	431	389	8.0
	Apr.1948	2,441	.06	80	28	282	70	4	9.2	354	315	7.7
	Aug.1948	246	.04	91	35	338	82	10	6.0	426	371	7.9

a/ Values in terms of mg/l, except pH and Color.

b/ As $CaCO_3$.

TABLE V-3

Groundwater Quality[a/]

Proposed Buck Creek Reservoir Project

Location	Date Sampled	Aquifer	Fe	Ca	Mg	HCO_3	SO_4	Cl	NO_3	Dissolved Solids	Hardness[b/]	pH
Dayton - City of	Apr.1947	Valley Train Shallow Well	0.30	90	32	287	87	8.9	7.3	406	356	7.9
	Apr.1947	Valley Train Deep Well	1.5	85	34	355	60	8.8	.0	379	352	7.8
National Cash Register Co.	Apr.1947	Valley Train	.05	92	38	350	88	34	.5	475	386	7.8
Johnsville Church	May 1947	Upland Glacial Deposits	.41	54	25	123	250	3.2	0.1	485	238	7.4
Private Well	May 1947	Silurian Limestone	.76	81	44	460	25	10	2.0	433	383	7.1
United Fireworks Company	May 1947	Ordivician Shale	.14	102	44	371	71	39	36	522	435	7.3

a/ Values in terms of mg/l, except pH.

b/ As $CaCO_3$.

TABLE VI-1

Number of Manufacturing Plants in the Study Area by Counties and Size, 1964

Proposed Buck Creek Reservoir Project

	Employment Categories							
	20-49	50-99	100-249	250-499	500-999	1,000-2,499	2,500 +	Total
Butler County	22	9	25	10	6	1	3	76
Clark County	28	18	16	6	4	0	1	73
Miami County	20	11	16	9	2	1	0	59
Montgomery County	125	58	60	19	11	6	8	287
Totals	195	96	117	44	23	8	12	495

Source: McGraw-Hill Industrial Establishment Summary, unpublished.

TABLE VI-2

Employment Detail for Selected Industries in the Study Area by Counties, 1962

Proposed Buck Creek Reservoir Project

SIC Code	Industry	Number of Employees
Butler County		
262	Paper Mills except building paper	2,837
263	Paperboard Mills	394
2641	Paper Coating and Glazing	1 plant over 500 employees
265	Paperboard Containers	943
3312	Blast Furnaces and Steel mills	5,695
3321	Gray Iron Foundries	469
Miami County		
2011	Meat Packing Products	1,002
Montgomery County		
2011	Meat Packing Products	615
2026	Fluid Milk	1,097
262	Paper Mills except building paper	1,500
264	Paper and Paperboard Products	1,784
284	Cleaning and Toilet Goods	301
2851	Paints and Varnishes	411
289	Miscellaneous Chemical Products	330
332	Iron and Steel Foundries	1,720
347	Coating, Engraving and Allied Services (includes plating)	545

Source: County Business Patterns, 1962

TABLE VI-5

Employment and Output in Selected Industrial Categories in the Study Area by Counties, 1962 and Indices of Output 1980 and 2010

Proposed Buck Creek Reservoir Project

SIC Code	Industrial Category	1962 Employment	1962 Output ($000)	Index of Output 1962-100	
				1980	2010
Butler County					
All Manufacturing		25,666			
20	Food & Kindred Products	728	28,028	177	442
26	Paper & Allied Products	5,962	178,860	237	590
33	Primary Metals	6,164	166,428	145	250
34	Fabricated Metals	2,327	53,056	194	490
35 & 36	Machinery	2,270	44,946	199	401
Clark County					
All Manufacturing		15,082			
20	Food & Kindred Products	738	28,413	177	442
33	Primary Metals	712	19,224	143	250
34	Fabricated Metals	981	22,367	194	490
35 & 36	Machinery	4,453	88,169	197	401
37	Transportation Equipment	3,243	90,480	281	751
38	Instruments & Related Items	404	6,585	252	800
39	Miscellaneous Manufacturing	882	14,377	252	800
Miami County					
All Manufacturing		10,130			
20	Food & Kindred Products	1,187	45,700	177	442
22	Textiles	830	9,877	149	33
26	Paper & Allied Products	752	22,560	237	590
33	Primary Metals	363	9,801	144	250
34	Fabricated Metals	649	14,797	195	490
35 & 36	Machinery	4,166	82,487	198	401
Montgomery County					
All Manufacturing		85,583			
20	Food & Kindred Products	3,929	151,184	177	442
26	Paper & Allied Products	3,885	116,550	237	590
28	Chemicals	1,337	48,744	185	433
29	Petroleum Refining	226	6,780	204	590
33	Primary Metals	2,201	59,588	143	250
34	Fabricated Metals	2,464	56,145	194	490
35 & 36	Machinery	46,995	928,151	198	401

Source: Employment - County Business Patterns, 1962; productivity - A. D. Little Company, Inc. Projective Economic Study of the Ohio River Basin.

TABLE VII-1

Study Area - Water Resources and Supplies - Municipal - 1960

Proposed Buck Creek Reservoir Project

Location and Name of Municipality	Population Served	Average Use	
		Ground mgd	Surface mgd
Mad River			
Springfield Service Area			
Springfield	90,000	14.148	-
Northridge S.D.	1,850	0.152	-
Subtotal	91,850	14.300	-
Miami River			
Dayton Service Area			
Fairborn (Mad River)	22,000	2.000	-
Dayton	320,000	50.000	-
Greater Moraine W.S.	74,440	8.000	-
West Carrollton	5,500	0.350	-
Miamisburg	10,500	1.000	-
Subtotal	432,440	61.350	-
Middletown Service Area			
Franklin	10,000	1.000	-
Middletown	45,000	7.200	-
Trenton	3,300	0.200	-
Subtotal	58,300	8.400	-
Hamilton Service Area			
New Miami	3,500	0.161	-
Hamilton	74,000	7.347	-
Fairfield	7,800	0.500	-
Subtotal	85,300	8.008	-
Venice-Cleves Service Area			
Venice	-	-	-
Fernald	-	-	-
Cleves	2,955	0.200	-
Subtotal	2,955	0.200	-
Total	670,845	92.258	-

TABLE VII-2

Study Area - Water Resources and Supplies - Industrial - 1955 [a]

Proposed Buck Creek Reservoir Project

Location and Name of Municipality	Total mgd	From Public Supplies mgd	Self-Supplied Ground mgd	Self-Supplied Surface mgd	Amount used for cooling mgd	Percent used for Cooling
Mad River						
Springfield Service Area						
Springfield	3.053	2.237	0.816	-	1.602	52.4
Northridge S.D.	-	-	-	-	-	-
Subtotal	3.053	2.237	0.816	-	1.602	52.4
Miami River						
Dayton Service Area						
Fairborn (Mad River)	1.495	-	1.495	-	0.268	17.9
Dayton	56.855	16.604	36.553	3.698	37.202	65.4
Greater Moraine W.S.	-	-	-	-	-	-
West Carrollton	6.431	0.010	6.421	-	0.147	2.2
Miamisburg	0.156	0.140	0.016	-	0.118	75.6
Subtotal	64.937	16.754	44.485	3.698	37.735	58.1
Middletown Service Area						
Franklin	3.514	0.168	3.346	-	1.126	32.0
Middletown	21.322	0.353	20.908	0.061	5.377	25.2
Trenton	-	-	-	-	-	-
Subtotal	24.836	0.521	24.254	0.061	6.503	26.2
Hamilton Service Area						
New Miami	10.760	-	10.760	-	7.424	68.9
Hamilton	4.962	0.937	2.788	1.237	2.625	52.9
Fairfield	0.388	0.003	0.382	0.003	0.045	11.5
Subtotal	16.110	0.940	13.930	1.240	10.094	62.6
Venice-Cleves Service Area						
Venice	11.400 [b]	-	11.400 [b]	-	-	-
Fernald	0.101	-	0.101	-	0.070	69.3
Cleves	33.832	-	7.466	26.366	32.791	96.9 [c]
Subtotal	45.333	-	18.967	26.366	32.861	96.8
Total	154.269	20.452	102.452	31.365	88.795	62.2 [c]

a/ Industries not identified by name.

b/ Diverted to Mill Creek drainage basin.

c/ Not including water diverted to Mill Creek.

TABLE VII-3

Other Communities in the Basin - Water Resources and Supplies - Municipal - 1960

Proposed Buck Creek Reservoir Project

Location and Name of Municipality	Population Served	Average Use Ground mgd	Average Use Surface mgd
Miami River - Upper			
Bellefontaine	12,000	2.450	-
Russels Point	2,200	0.143	-
Lakeview	1,010	0.115	-
Sidney	14,700	1.200	-
Piqua	19,980	-	3.400
Troy	15,000	1.430	-
New Carlisle	4,200	0.300	-
Tipp City	4,235	0.796	-
Vandalia	7,600	1.000	-
Subtotal	80,925	7.434	3.400
Loramie Creek			
Minster	2,195	0.400	-
Subtotal	2,195	0.400	-
Mad River (Upper)			
St. Paris	1,460	0.090	-
West Liberty	1,500	0.100	-
Urbana	10,460	1.500	-
Subtotal	13,420	1.690	-
Twin Creek			
Lewisburg	1,500	0.110	-
West Alexandria	1,700	0.130	-
Germantown	3,500	0.300	-
Subtotal	6,700	0.540	-
Stillwater River			
Greenville	10,500	-	1.500
Ansonia	1,000	0.210	-
Arcanum	1,750	0.110	-
Union City	1,655	0.175	-
Bradford	2,150	0.150	-
Versailles	2,200	0.230	-
Covington	2,800	0.450	-
Pleasant Hill	1,000	0.100	-
West Milton	3,000	0.280	-
Englewood	4,000	0.350	-
Subtotal	30,055	2.055	1.500
Four Mile Creek			
Eaton	5,000	0.550	-
Camden	1,200	0.080	-
Oxford	13,000	1.400	-
Subtotal	19,200	2.030	-
Minor Tributaries			
Wolf Creek			
Brookville	3,505	0.200	-
Subtotal	3,505	0.200	-
Bear Creek			
New Lebanon	2,400	0.240	-
Subtotal	2,400	0.240	-
Total	158,400	14.589	4.900

TABLE VII-4

Other Communities in the Basin - Water Resources and Supplies - Industrial - 1955

Proposed Buck Creek Reservoir Project

Location and Name of Municipality	Total mgd	From Public Supplies mgd	Self-Supplied Ground mgd	Self-Supplied Surface mgd	Amount used for cooling mgd	Percent used for Cooling
Miami River - Upper						
Bellefontaine	0.369	0.369	-	-	0.112	30.3
Russels Point	-	-	-	-	-	-
Lakeview	-	-	-	-	-	-
Sidney	0.293	0.253	0.040	-	0.031	10.5
Piqua	0.867	0.694	0.173	-	0.105	12.1
Troy	1.169	0.234	0.935	-	0.495	42.3
New Carlisle	-	-	-	-	-	-
Tipp City	0.655	0.281	-	0.374	0.145	22.1
Vandalia	0.758	0.480	0.278	-	0.187	24.6
Subtotal	4.111	2.311	1.426	0.374	1.075	26.2
Loramie Creek						
Minster	0.054	0.048	0.006	-	0.018	33.3
Subtotal	0.054	0.048	0.006	-	0.018	33.3
Mad River (Upper)						
St. Paris	-	-	-	-	-	-
West Liberty	-	-	-	-	-	-
Urbana	4.104	0.120	2.697	1.287	3.094	75.3
Subtotal	4.104	0.120	2.697	1.287	3.094	75.3
Twin Creek						
Lewisburg	0.003	0.003	-	-	-	-
West Alexandria	0.011	0.011	-	-	0.007	63.6
Germantown	0.152	0.004	0.148	-	0.134	88.1
Subtotal	0.166	0.018	0.148	-	0.141	84.9
Stillwater River						
Greenville	1.257	0.096	0.121	1.040	1.048	83.3
Ansonia	-	-	-	-	-	-
Arcanum	0.001	0.001	-	-	.001	100.
Union City	-	-	-	-	-	-
Bradford	0.003	0.003	-	-	-	-
Versailles	0.001	0.001	-	-	-	-
Covington	0.327	0.265	0.062	-	0.304	93.9
Pleasant Hill	-	-	-	-	-	-
West Milton	-	-	-	-	-	-
Englewood	-	-	-	-	-	-
Subtotal	1.589	0.366	0.183	1.040	1.353	85.1
Four Mile Creek						
Eaton	0.011	0.011	-	-	0.001	9.0
Camden	0.001	0.001	-	-	-	-
Oxford	-	-	-	-	-	-
Subtotal	0.012	0.012	-	-	0.001	8.3
Total	10.036	2.875	4.460	2.701	5.682	56.6

TABLE VIII-1

Study Area - Wastes and Waste Loads - Municipal and Industrial

Proposed Buck Creek Reservoir Project

Location and Name of Municipality	Municipal 10/ P.E. of Untreated Waste	mgd	Treatment	P.E. Discharge	Self Discharging Industrial 9/ P.E. Untreated Waste
Mad River					
Springfield Service Area					
Springfield	94,800	19.40	Sec.	8,050 (Est.)	-
Subtotal	94,800			8,050	
Miami River					
Dayton Service Area					
Fairborn	16,800	1.68	Sec.	3,020	-
Trotwood	5,240	0.54	Sec.	455	-
Dayton	360,000	41.00	Sec.	48,500	50,120
Dayton-Moraine S.D.	17,500	2.00	Sec.	3,500	19,700
Montgomery Cty.-Beaver S.D.	37,900 a/	5.11	Sec.	5,360 a/	-
West Carrollton	4,750	-	Sec.	705(Est.)	187,500
Miamisburg	9,500	0.87	Prim.	5,140	29,850
Subtotal	413,790			66,680	287,170
Middletown Service Area					
Franklin	5,320	0.40	Sec.	1,040	65,610
Middletown	63,100	7.88	Prim.	43,500	83,100
Excello	-	-	-	-	26,820
Trenton	-	-	-	-	-
Subtotal	68,420			43,540	175,530
Hamilton Service Area					
New Miami	-	-	-	-	-
Hamilton	55,200	6.27	Sec.	8,130	209,000
Fairfield	-	-	-	-	-
Subtotal	55,200			8,130	209,000
Venice-Cleves Service Area					
Venice	-	-	-	-	2,770
Fernald	-	-	-	-b/	-
Cleves	2,075	0.10	-	-	90,000
Subtotal	2,075				92,770

a/ Discharge to Little Miami River Basin, not included in Subtotal.

b/ Discharge to Ohio River.

TABLE VIII-2

Other Communities in the Basin - Water Resources and Supplies - Municipal and Industrial

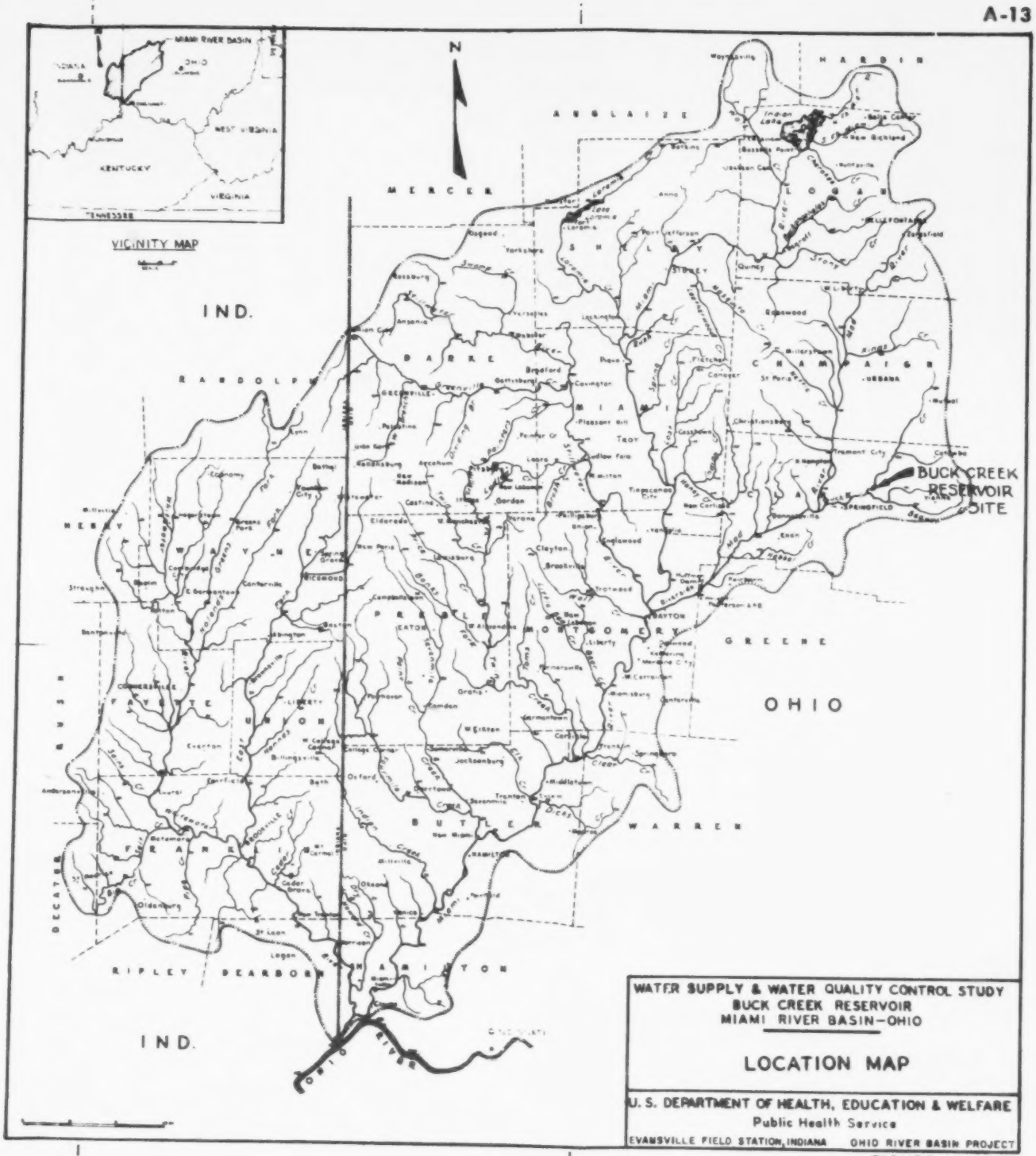
Proposed Buck Creek Reservoir Project

Location and Name of Municipality	Municipal				Self Discharging Industrial
	P.E. of Untreated Waste	mgd	Treatment	P.E. Discharge	P.E. Untreated Waste
Miami River - Upper					
Bellefontaine	11,450	0.90	Sec.	1,940	-
Russells Point S.D.	3,350	0.57	Sec.	240	-
Lakeview	Discharges to Russels Point				
Sidney	13,250	0.88	Sec.	970	7,310
Piqua	22,100	2.59	Sec.	5,700	-
Troy	15,700	1.04	Sec.	2,310	40,130
New Carlisle	1,110	0.12	Sec.	110	-
Tipp City	2,810	0.25	Sec.	375	10,470
Vandalia	4,720	0.49	Septic Tank	3,490	-
Subtotal	74,490			15,135	57,910
Loramie Creek					
Minster	4,120	0.26	Sec.	275	-
Subtotal	4,120			275	-
Mad River (Upper)					
St. Paris	1,460	0.06	Sec.	300	-
West Liberty	1,520	0.50	Prim.	700 (est.)	-
Urbana	7,520	1.175	Sec.	165	21,270
Subtotal	10,500			1,165	21,270
Twin Creek					
Lewisburg	1,415	-	Septic Tank	945	-
West Alexandria	1,525	-	Septic Tank	1,000	-
Germantown	3,340	0.23	Sec.	185	-
Subtotal	6,280			2,130	-
Stillwater River					
Greenville	8,730	0.73	Sec.	1,460	-
Ansonia	1,000	-	None	1,000	-
Arcanum	1,680	-	None	1,680	-
Union City	4,540	0.28	Sec.	680	-
Bradford	2,150	-	None	2,150	-
Versailles	2,740	0.15	Int.	965	-
Covington	7,000	0.22	Sec.	45	-
Pleasant Hill	1,060	-	Septic Tank	740	-
West Milton	2,970	0.323	Prim.	1,340 (est.)	-
Englewood	1,615	0.135	Prim.	745 (est.)	-
Subtotal	33,485			10,785	-
Four Mile Creek					
Eaton	6,300	0.400	Sec.	700	-
Camden	1,310	-	Septic Tank	880	-
Oxford	5,960	0.81	Sec.	1,020	-
Subtotal	13,570			2,600	-
Minor Tributaries					
Wolf Creek					
Brookville	3,185	0.30	Sec.	230	-
Subtotal	3,185			230	-
Bear Creek					
New Lebanon	1,580	0.16	Sec.	315	-
Subtotal	1,580			315	-

TABLE VIII-3

Study Area - Future Wastes and Waste Loads - Municipal and Industrial
Proposed Buck Creek Reservoir Project

Location and Name of Municipality	1980 P.E. Untreated Waste		2000 P.E. Untreated Waste		2020 P.E. Untreated Waste	
	Municipal	Industrial	Municipal	Industrial	Municipal	Industrial
Mad River						
Springfield Service Area						
Springfield	133,500	-	160,000	-	182,400	-
Subtotal	133,500	-	160,000	-	182,400	-
Miami River						
Dayton Service Area						
Fairborn	25,200	-	33,600	-	49,000	-
Dayton	639,600	61,000	853,000	67,000	1,244,000	73,000
Dayton-Moraine S.D.	33,600	-	44,600	-	65,000	-
West Carrollton	7,200	229,000	9,600	251,000	14,000	274,000
Miamisburg	14,400	36,400	19,200	40,000	28,000	43,600
Subtotal	720,000	326,400	960,000	358,000	1,400,000	390,600
Middletown Service Area						
Franklin	11,500	80,000	15,300	88,000	18,700	96,000
Middletown	83,000	101,500	110,000	111,500	135,000	121,500
Excello	-	-	-	36,000	-	39,200
Subtotal	94,500	181,500	125,300	235,500	153,700	256,700
Hamilton Service Area						
Hamilton	90,000	255,000	190,000	280,000	240,000	306,000
Subtotal	90,000	255,000	190,000	280,000	240,000	306,000
Venice-Cleves Service Area						
Venice	-	3,400	-	3,700	-	4,000
Cleves	-	110,000	-	121,000	-	131,500
Subtotal	-	113,400	-	124,700	-	135,500



WATER SUPPLY & WATER QUALITY CONTROL STUDY
BUCK CREEK RESERVOIR
MIAMI RIVER BASIN—OHIO

LOCATION MAP

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
Public Health Service
EVANSVILLE FIELD STATION, INDIANA OHIO RIVER BASIN PROJECT

FIGURE 1